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ON THE LIFE HISTORY OF *DAVAINEA TETRAGONA* (MOLIN), A FOWL TAPEWORM *

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Further experimental studies by the writer on the life histories of fowl cestodes have demonstrated that tapeworms which appear to be *Davainea tetragona* (Molin) may be transmitted to *Gallus domesticus* by feeding them *Musca domestica* Lin. That this fly may be the means of transmitting other fowl cestodes is known. Grassi and Rovelli (1892: 33, 87) found in its body larvae whose scolices closely resembled those of *Choanotaenia infundibuliformis* (Goeze), while Gutberlet (1916: 235) succeeded both in infecting *M. domestica* with cysticerci by feeding onchospheres of this tapeworm, and in rearing adult worms by giving to fowls house flies taken from nature. And the writer (1918: 41) reared *Davainea cesticillus* (Molin) in *Gallus domesticus* by feeding *M. domestica* which some weeks previously had been given onchospheres of this cestode.

In the present experiment, chicks hatched in incubators were taken under cover to one of two experimental feeding houses which had been fumigated ten hours with sodium cyanide and thoroughly cleaned. The cement floors and 18-inch walls excluded worm-like animals, while the screened openings and enclosed vestibules facilitated in eliminating winged forms. On entering the vestibule any intruder was captured before proceeding to the interior of the feeding house. Extreme care was exercised in administering the food, the uncooked portion containing no animal tissues except occasional feedings of fresh beef, and of course, the experimental feedings. By these methods, which have been employed during the last five years, control chicks running with the experimental ones have been free from parasitic worms in every case. It is possible that an occasional arthropod may enter through the fourteen-mesh window screens, but the control chicks have equal opportunity with the experimental ones for ingesting such forms. The chances of such animals being infected with fowl tapeworm larvae are minimized owing to the fact that the experimental feeding houses are 250 yards from a poultry yard.

In September, 1918, several poultry yards in the vicinity of Manhattan, Kansas, were visited. Spring chicks were examined, and at two places *D. tetragona* were among the tapeworms found. In the

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chicken houses and under roosts the freshly voided feces were covered with flies, many of which were *M. domestica.* At these places large fly traps were set near the chicken houses and thousands of flies trapped. From day to day the traps were collected and immersed in tap water for several hours to facilitate identification of the flies. It was found that the latter could be removed from the traps, slightly dried, and the *M. domestica* sorted out one by one before they recuperated sufficiently to escape. They were then given to chicks reared in the experimental feeding houses. When the flies were immersed seventeen hours and then placed by an open window, large numbers recovered fully in two and one-half to three hours after their removal from the water. Among the lots of *M. domestica* given to the experimental chickens were many flies making random movements indicating that any possible tapeworm larvae in their bodies were probably uninjured by the immersion.

Numerous *M. domestica,* obtained in this way, were given as follows to chicks 2½ months old during the autumn of 1918: 3,506 flies to each of chicks 233, 234 and 235 in eighteen feedings, ranging from thirty-nine to 493 between September 23 and October 19; 3,467 flies to chick 236 in seventeen feedings, varying from eighty-nine to 493 between September 24 and October 19; 2,938 flies to each of chicks 239, 240, 241, 242, 243, 245, 246 and 247 in fifteen lots of flies, numbering from 260 to 493 between September 30 and October 19, and 2,026 flies to each of chicks 248, 249, 250 and 251 in thirteen feedings of fifty to 290 from October 4 to October 19.

Early in November, six weeks after the first feeding of flies, four chicks were examined. Two of these were negative, but the other two had mature tapeworms in their intestines, chick 235 having ten long worms, and chick 250 two medium-sized ones, all of which were sexually mature, and some of them possessed gravid proglottids. Two of the control chicks which had been running with the experimental ones were killed, and the examination showed that their intestines were free from parasitic worms. One month later two large tapeworms were found in the intestine of chick 249. During the next eighteen days ten control chicks were examined, and every one of them was free from helminths. In the same period, examinations of the remaining eleven experimental chicks showed that none of these was infected.

Morphological studies of several of the cestodes obtained are here recorded. These tapeworms vary in length from 31 to 307 mm., and from 1 to 3 mm. in width. The scolices measure 247 to 410μ long by 187 to 394μ wide, and are provided with retractile rostella varying from 49 to 57μ in breadth, each armed with a single row of about 100 hooks, 7 to 8μ long. A short dorsal root and a long ventral one are characteristic of each rostellar hook which is provided with a small, recurved prong. The oval suckers measure 94 to 170μ in longitudinal diameter by 53 to 82μ in transverse diameter, and are armed with eight to ten rows of minute hooks varying in length from 5 to 8.75μ. Of the two short roots, the ventral is slightly the longer, but it is shorter than the prong, which is slender and curved. The neck is long and slender. The proglottids are trapezoidal and imbricate, and the edge of the strobila is serrate. Nearly all of the proglottids are broader than long, the width of the anterior ones being two and one-half to four times the length, that of the middle ones, two to two and one-half times the long axis, and the breadth of the posterior segments, twice the length or about equal to it, depending on the age of the worm. The unilateral genital pores, numbering one in each segment, are situated at or in front of the middle of the lateral margin and are marked occasionally by papillae. The vas deferens and vagina pass on the dorsal side of the nerve, but between the excretory vessels.

Of the male genitalia, the testes, numbering 21 to 25, lie in the median portion, mostly on the aporose side of the proglottid. The vas deferens lies in the anterior third of the segment; it begins near the middle and extends laterally in a much convoluted course to the base of the cirrus pouch which it enters; after two or three coils it becomes continuous with the cirrus which, apparently, is without spines. The pyriform cirrus pouch, measuring 77 to 84μ in length, is surrounded by a layer of muscles 3.5μ thick.

A branched ovary in the middle of the proglottid is the most conspicuous part of the female genitalia. Posterior and slightly to the left of the ovary is the yolk gland, somewhat reniform, with a diameter ranging from 90 to 114μ. The shell gland, lying in front of the yolk gland and dorsal to it, may vary from 52 to 60μ in diameter. The vagina begins at the genital pore posterior to the cirrus pouch; at first it is slender, but at a distance of about 15μ it widens into a thin-walled tube adapted for a seminal receptacle which extends transversely across the proglottid, passing dorsal to the nerve and between the two excretory vessels to the middle of the segment where it bends posteriorly and ventrally, joining the oviduct immediately behind the ovary. After connecting with the vitelloduct in the shell gland, the oviduct extends forward and ends on the dorsal side of the ovary. A persistent uterus is not formed. The eggs pass from the distal end of the oviduct and become imbedded in a fibrous, granular mass which ultimately fills most of the proglottid. This structure divides into 40 to 114 parts, forming egg masses, each of which contains six or more eggs, and is surrounded by a membrane. The individual egg has three envelopes: an inner, surrounding the onchosphere; a middle, somewhat wrinkled; and a smooth, outer covering. The diameter of the onchosphere is approximately 11μ, while that of the outer envelope is about 46μ.

From these studies it seems evident that several of the cestodes obtained are *Davainea tetragona* Blanchard 1891 (in part[1]). Certain variations in structure occur which, hitherto, have not been recorded for this cestode, but they are more nearly in accord with *D. tetragona* than with the somewhat closely related species, *D. echinobothrida* Blanchard 1891. The length of the longest of these cestodes is 307 mm., while the maximum length recorded for either of the above species is 250 mm. Of these tapeworms the maximum width of scolex is 394μ as compared with 350μ given by Ransom (1904: 278) for this worm, and 450μ by the same author for *D. echinobothrida.* The maximum longitudinal diameter of the suckers of the cestodes in question is 170μ, which exceeds the maximum recorded size for this worm 60μ, and lacks 30μ of attaining the greatest diameter of the suckers of *D. echinobothrida,* according to Gutberlet (1916: 36). In these cestodes, the vagina and vas deferens pass between the excretory vessels instead of dorsal to them as is usually recorded for *D. tetragona.* The number of egg masses reported for this tapeworm varies from 50 to 100, but gravid proglottids of the cestodes under consideration may have from 40 to 114 such masses. These small differences in size and structure, in the writer's opinion, should be considered only as variations in the morphology of *D. tetragona.*

The evidence presented points to *M. domestica* as an intermediate host of *D. tetragona,* but thus far larvae of this tapeworm have not been found in the house fly. As the onchospheres are in masses several times the diameter of an embryo, it seemed possible that *M. domestica* might not be able to ingest them. Accordingly, tests were made. Lot 424, consisting of six *M. domestica* were offered fifty egg masses from a live proglottid in a small drop of sweetened water on a glass slide. In three minutes two of the flies took all the moisture, whereupon the slide was examined microscopically, and of the fifty egg masses twenty-nine remained on the slide. In a second similar trial sixteen egg masses were taken, and in two others, six masses were ingested. Moreover, the walls of some of the egg masses had been ruptured by the sucking of the flies which drew out some of the enclosed onchospheres. The adaptability of flies' feet for carrying small organisms made a careful scrutiny for the adherence of egg masses imperative. In one case a mass was carried approximately an inch before it fell from the foot of the fly. These tests showed that egg masses of *D. tetragona* can be ingested by *M. domestica,* and that the latter may take separate onchospheres from the egg masses.

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[1] R. Blanchard (Notices Helminthologiques. Mem. Soc. Zool. France, 4: 436) records a double row of about 200 rostellar hooks, and circular suckers for this worm. The latter are clearly oval in all of these specimens. Under ordinary magnification the rostellar hooks appear to be arranged in a double row, but with the aid of an oil immersion objective individual hooks may be seen throughout their length, and their number in a definite arc of the rostellum counted.

Having determined that onchospheres of this tapeworm are ingested by *M. domestica,* two questions arose: Are ingested egg masses or onchospheres regurgitated by the flies and lost? Do the onchospheres pass through the digestive tract of the flies unaltered? It is known that *M. domestica* after gorging itself with liquid food usually regurgitates, forcing out of the crop through the proboscis a portion of this food. The latter frequently takes the form of a bubble adhering to the withdrawn proboscis. At other times the regurgitated drop of liquid is placed on some object and, according to Graham-Smith (1913: 69, 86), it is then gradually taken into the stomach of the fly. In such cases the object is marked by a relatively large, regurgitation spot with a characteristic, light center surrounded by an opaque, marginal ring. These flat regurgitation spots are easily distinguished from the cone-shaped fecal specks of smaller diameter and darker color. In regurgitating it would not be surprising if ingested egg masses or separate onchospheres would be left in the regurgitation spots. To determine this point, small test cages were constructed, every part of which was capable of being examined by the compound microscope. The four walls were made of glass slides, 38x75 mm., the corners being sealed with melted paraffin. The top of the cage consisted of a glass plate 38 mm. square, which was held in place by strips of gummed labels, while a glass slide served as the base of the cage. In these test cages, the house flies behave normally and lived several days.

As the answers to both questions were obtained from the same experiments, the preliminary tests for solving the second question are given here. To ascertain whether or not the onchospheres go through the flies unaltered, it was necessary to learn the length of time required for the passage of food through their digestive tracts. Several tests were made, a typical one being described in detail. Three *M. domestica* (lot 309) taken from a trap baited with vinegar and corn syrup, were placed in one of the test cages where they were given a few drops of sweetened water colored red by the addition of carmine grains. That the flies fed freely was evident from the bright red appearance of the anteroventral portions of their abdomens — the areas immediately below their crops. Each fly regurgitated once. After fifteen minutes the base slide with the remaining red liquid was removed and a clean one substituted. Two hours and thirty-eight minutes later four characteristic red fecal specks appeared. During the ensuing three hours, six specks, respectively, were defecated, while a maximum of ten were deposited during the seventh hour after feeding. In the next two hours the number of specks in the cage was increased by only five. The tenth hour showed an addition of six faintly red fecal specks, and in the eleventh hour after feeding there were four defecations which contained so few carmine grains that the latter were visible only by aid of a microscope.

To be certain that the red color of the fecal specks was due to the carmine and not to the vinegar and syrup with which the trap had been baited, the fecal deposits from lots 283-303 of *M. domestica*, isolated in lantern globes from the same trap, were carefully examined. Not one of the several hundred specks was colored red, and examination with a lens confirmed the absence of any red particles.

Other similar tests for ascertaining the length of time required for food to pass through the digestive tract of *M. domestica* were made with fresh blood. In these cases, the feces were voided in nine to twelve hours which is approximately the same period as that determined by Gutberlet (1916: 233) in similar tests on flies. On the other hand, sweetened water and carmine grains, before mentioned, were voided in at least two hours and thirty-eight minutes, and in a test with whole, sweet milk and powdered carmine the bright red fecal specks appeared in one hour and fifty-five minutes. The evidence here presented indicates that the time required for liquid food to pass through the digestive tract of *M. domestica* may vary from one hour and flfty-five minutes to twelve hours.

Having ascertained the approximate period of time required for the passage of liquid food through the body of the house fly, attention was directed to the questions of the egg masses or onchospheres being lost by regurgitation, and of their passing through the alimentary canal unaltered. To determine these points, lots 430 and 431, consisting of six and four *M. domestica,* respectively, were isolated in test cages. Gravid proglottids of *D. tetragona* from freshly voided chicken feces were teased in slightly sweetened tap water. In this medium, fifty-six egg masses were offered to lot 430, and ninety to lot 431. The first lot took seven masses, and the second twelve. As each mass contains six or more onchospheres, lot 430 took at least thirty-six of these embryos and lot 431 a minimum of seventy-two. After feeding the egg masses, each lot of flies was transferred to a clean test cage, whereupon the vacated cages were pried apart and every regurgitation spot examined by the aid of a compound microscope. No structure resembling either an egg mass or an onchospher was present in any of the spots. At two-hour intervals the flies were transferred to clean test cages, and each fecal speck studied, a mechanical stage being used to locate the fecal deposits. The examination of these specks was continued until the nineteenth hour after feeding the egg masses. In one instance a globular-shaped structure about the size of an onchosphere occurred in a speck, but it lacked hooks and internal membranes.

From this test and from those made on the eggs of *D. cesticillus* which will be reported in a later paper, it seems evident that few, if any, ingested onchospheres of the cestode in question are either lost by regurgitation or passed through the digestive tracts of these flies unaltered. This evidence and the morphological studies on fourteen adult tapeworms obtained by giving common house flies from infected poultry yards to experimental chicks lead the writer to conclude that *M. domestica* may be the means of transmitting *D. tetragona* from one fowl to another.

SUMMARY

1. Flies trapped at poultry yards infested with *Davainea tetragona* (Molin) and other tapeworms were given (many alive) to young chicks reared in a screened house. The food of all controls was free from animal tissues.

2. In two months the chicks were examined; three contained mature tapeworms, several with embryos. The twelve control chicks were free from parasitic worms.

3. Flies eat both onchospheres and egg masses of *D. tetragona,* and neither when ingested are lost by regurgitation, or passed through the digestive tract unaltered.

4. As common house flies from infected poultry yards constituted the only difference between the food given to the experimental chicks and that fed to the control chicks, evidently *D. tetragona* may be transmitted from one fowl to another by *M. domestica.*

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